HOMEWORK SET 3 SOLUTIONS.

1. $T_c = 38.7°C$

$T_K = T_c + 273.15 = 311.9K$

$[T_K = 311.9K]$

$T_F = \frac{9}{5} T_c + 32 = 101.7°F$

$[T_F = 101.7°F]$

CQ 2. $V_1 = V_2$

$p_1 = p_2$ since $pV = nRT$

$T_1 = T_2$

$n_1 = n_2$ THE # OF MOLES ARE THE SAME

SINCE $n = \frac{N}{N_A}$ THE TOTAL # OF PARTICLES ARE THE SAME

(IE THE TOTAL NUMBER OF PARTICLES ARE THE SAME ∴ THE VOLUMES ARE THE SAME)

[THE # DENSITIES ARE THE SAME]

ALSO SINCE $n = \frac{M}{M_{MOL}}$ ∴ $M = n M_{MOL}$ SINCE $M_{MOL,N_2} = 0.028\ kg/mol$

$M_{mol,He} = 0.004\ kg/mol$

∴ $M_{N_2} > M_{He}$ SINCE $V_{N_2} = V_{He}$

$[\rho_{N_2} > \rho_{He}]$

[THE MASS DENSITY OF N_2 IS 7 TIMES LARGER THAN THE MASS DENSITY OF He]

CQ3 SEALED CONTAINER IMPLIES THAT THE # OF MOLES, n, IS FIXED

$T_2 = 2T_1$

$V_2 = 3V_1$

a) NOW $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} = \frac{p_2 \cdot 3V_1}{2T_1}$

SO

$p_1 = \frac{3}{2} p_2 \quad \therefore \left[p_2 = \frac{2}{3} p_1 \right]$

b) SINCE $n_1 = n_2$, $N_1 = N_2$

SO $\frac{N_2}{V_2} = \frac{N_1}{3V_1} = \frac{1}{3}\left(\frac{N_1}{V_1}\right)$

$\left[\frac{1}{3}\right]$

CQ4 ISOBARIC PROCESS IMPLIES $p_2 = p_1 \equiv p$

$V_2 = 3V_1$ NOW $pV_1 = nRT_1$ SO $\frac{V_2}{V_1} = \frac{T_2}{T_1} = 3$

$pV_2 = nRT_2$

SO $T_3 = 3T_1$

$[3]$

P1 $n = 1.10 \text{ moles}$

$V = 0.0268 m^3$

$p = 1.15 ATM \times \frac{1.01 \times 10^5 Pa}{1 ATM} = 1.16 \times 10^5 Pa$

a) $pV = nRT$ so $T = \frac{pV}{nR} = \frac{(1.16 \times 10^5 Pa)(0.0268 m^3)}{(1.10 \text{ moles})(8.31 J/mol K)} = 340. K = 3.4 \times 10^2 K$

b) $\frac{N}{V}$? $n = \frac{N}{N_A}$ so $N = nN_A = (1.10 mol)(6.02 \times 10^{23} mol^{-1}) = 6.62 \times 10^{23}$

so $\left[\frac{N}{V} = \frac{6.62 \times 10^{23}}{0.0268 m^3} = 2.47 \times 10^{25} m^{-3} \right]$

NOW, THE MOLAR MASS FOR N_2 IS

$M_{mol} = 0.028 kg/mol$ so

$n = \frac{M}{M_{mol}}$ $\therefore$ $M = nM_{mol} = (1.10 mol)(0.028 kg/mol)$

$[M = 0.0308 kg]$

AND THE MASS DENSITY IS...

$\rho = \frac{M}{V} = \frac{0.0308 kg}{0.0268 m^3} = 1.15 kg/m^3$

$[\rho = 1.15 kg/m^3]$

P2 $V_1 = 4.65 \times 10^{-2} m^3$ $\quad V_2 = \frac{1}{10} V_1 = 4.65 \times 10^{-3} m^3$

$T_1 = 306K$ $\quad p_2 = 25.0 p_1 = 2.53 \times 10^6 Pa$

$p_1 = 1.01 \times 10^5 Pa$

SINCE IT IS ASSUMED THAT THE NUMBER OF MOLES, n, REMAINS CONSTANT

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \quad \text{so} \quad T_2 = \frac{p_2 V_2}{p_1 V_1} T_1 = \frac{(25.0 p_1)(1/10 V_1)}{p_1 V_1} T_1$$

$$= 2.5 T_1 = 2.5 (306K)$$

$$\therefore \left[T_2 = 765K \right]$$

P3 SINCE $pV = nRT$, $n = \frac{p_1 V_1}{RT_1} = \frac{p_2 V_2}{RT_2}$

$$= \frac{(1.01 \times 10^5 Pa)(4.65 \times 10^{-2} m^3)}{(8.31 J/mol \cdot K)(306K)} = 1.85 \text{ mol}$$

a) $\left[n = 1.85 \text{ mol} \right]$

b) SINCE $M_{mol} = 0.028 kg/mol$ $\therefore$

$$n = \frac{M}{M_{mol}} \quad \therefore M = n M_{mol} = (1.85 mol)(0.028 kg/mol)$$

$$\left[M = 0.0517 kg \right]$$

SO THE MASS DENSITY DURING THE INTAKE IS..

$$\rho_1 = \frac{M}{V_1} = \frac{0.0517 kg}{4.65 \times 10^{-2} m^3} = 1.11 kg/m^3$$

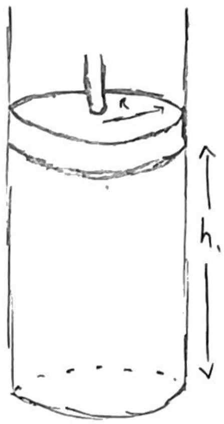
$$\therefore \left[\rho_1 = 1.11 kg/m^3 \right]$$

AND AFTER THE COMPRESSION..

$$\rho_1 = \frac{M}{V_2} = \frac{M}{\frac{1}{10} V_1} = 10 \frac{M}{V_1} = 10 \rho_1$$

$$\left[\rho_2 = 11.1 kg/m^3 \right]$$

P4



$M_{PISTON} = 28.0\,kg$

$A_{PISTON} = \pi R^2 = \pi(0.150m)^2 = 7.07\times10^{-2}\,m^2$

$h_1 = 0.960m$

$T_1 = 623K$

$P_{ATM} = 1.01\times10^5\,Pa$

NOW

a) $P_{GAS} = P_{ATM} + \dfrac{M_{PISTON}\,g}{A_{PISTON}} = (1.01\times10^5 Pa) + \dfrac{(28.0kg)(9.80m/s^2)}{7.07\times10^{-2}m^2}$

$$\boxed{P_{GAS} = 1.05\times10^5\,Pa}$$

b) NOTICE THAT THE PRESSURE OF THE GAS, P_{GAS}, AND THE # OF MOLES OF GAS, n, WILL REMAIN CONSTANT SO..

$P_{GAS}V_1 = nRT_1$ so $\dfrac{V_1}{V_2} = \dfrac{T_1}{T_2}$ $\therefore$ $V_2 = \dfrac{T_2}{T_1}V_1$

$P_{GAS}V_2 = nRT_2$

$T_2 = 308K$

NOW $V_2 = h_2 A$

$V_1 = h_1 A$

SO

$h_2 = \dfrac{T_2}{T_1}h_1 = \dfrac{(308K)}{(623K)}(0.960m)$

$$\boxed{h_2 = 0.475m}$$

P5. $n = 0.35\,mol$ of N_2 $\therefore M_{mol} = 0.028\,kg/mol$

$$V_1 = 55\,cm^3 \times \left(\frac{1\,m}{100\,cm}\right)^3 = 5.5\times10^{-5}\,m^3$$

$$T_1 = 298\,K$$

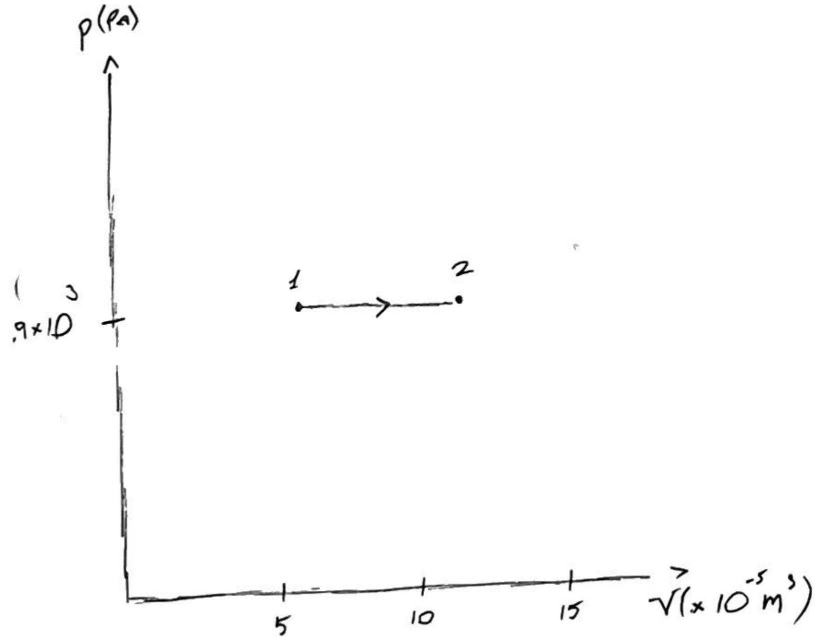
ISOBARIC HEATING IMPLIES $p_1 = p_2$

$$T_2 = 623\,K$$

NOW SINCE THE # OF MOLES, n, IS ALSO IMPLIED TO BE CONSTANT, WE HAVE...

$$pV_1 = nRT_1 \qquad pV_2 = nRT_2 \quad \Rightarrow \quad \frac{V_1}{V_2} = \frac{T_1}{T_2} \quad \Rightarrow \quad V_2 = \frac{T_2}{T_1}V_1 = \frac{(623K)}{(298K)}\left(5.5\times10^{-5}\,m^3\right)$$

$$\left[V_2 = 1.1\times10^{-4}\,m^3\right]$$



TO GET THE CONSTANT PRESSURE..

$$p = \frac{nRT_1}{V_1} = \frac{(0.35\,mol)(8.31\,J/mol\,K)(298K)}{(1.1\times10^{-4}\,m^3)}$$

$$= 7.9\times10^3\,Pa$$

P5. $n = 0.35\,mol$ of N_2 $\therefore M_{mol} = 0.028\,kg/mol$

$$V_1 = 55\,cm^3 \times \left(\frac{1\,m}{100\,cm}\right)^3 = 5.5\times10^{-5}\,m^3$$

$$T_1 = 298\,K$$

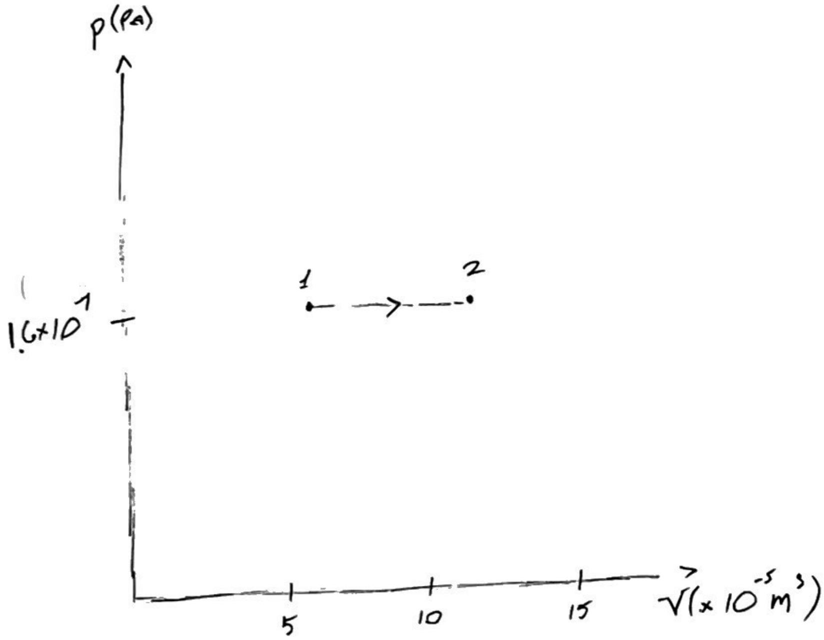
ISOBARIC HEATING IMPLIES $p_1 = p_2$

$$T_2 = 623\,K$$

NOW SINCE THE # OF MOLES, n, IS ALSO IMPLIED TO BE CONSTANT, WE HAVE...

$$\begin{aligned} pV_1 &= nRT_1 \\ pV_2 &= nRT_2 \end{aligned} \quad \text{a} \quad \frac{V_1}{V_2} = \frac{T_1}{T_2} \quad \text{so} \quad V_2 = \frac{T_2}{T_1}V_1 = \frac{(623K)}{(298K)}(5.5\times10^{-5}\,m^3)$$

$$\boxed{V_2 = 1.1\times10^{-4}\,m^3}$$



TO GET THE CONSTANT PRESSURE..

$$p = \frac{nRT_1}{V_1} = \frac{(0.35\,mol)(8.31\,J/mol\,K)(298K)}{(5.5\times10^{-5}\,m^3)}$$

$$= 1.6\times10^7\,Pa$$

P6 .. $M = 7.5\times10^{-3}\,kg$, THE MOLAR MASS OF O_2 IS $M_{MOL} = 0.032\,kg/mol$

$p_1 = 3.5\times10^{5}\,Pa$

$T_1 = 309K$

ISOCHORIC PROCESS IMPLIES $V_1 = V_2$, $p_2 = 3p_1$

a) THE NUMBER OF MOLES IS CALCULATED VIA...

$$n = \frac{M}{M_{MOL}} = \frac{7.5\times10^{-3}\,kg}{0.032\,kg/mol} = 0.23\,mol$$

b) $p_2 = 3(3.5\times10^{5}\,Pa) = 1.1\times10^{6}\,Pa$

$$\left[p_2 = 1.1\times10^{6}\,Pa\right]$$

c) $p_1V_1 = nRT_1$ DIVIDING YIELDS $3 = \frac{T_2}{T_1}$ SO $T_2 = 3T_1 = 3(309K)$

$p_2V_2 = (3p_1)V_1 = nRT_2$

$$\left[T_2 = 927K\right]$$

GAS VOLUME IS THEN DECREASED ISOBARICALLY IMPLIES $p_3 = p_2$ UNTIL $T_3 = T_1$

GOING FROM 2. TO 3. WE HAVE..

$p_2V_2 = nRT_2$ DIVIDING YIELDS $\frac{V_2}{V_3} = \frac{T_2}{T_3} = \frac{T_2}{T_1}$

$p_3V_3 = nRT_3$

SO

$$V_3 = \frac{T_1}{T_2}V_2 = \frac{T_1}{T_2}V_1 = \frac{(309K)}{(927K)}(1.7\times10^{-3}\,m^3)$$

NOW

$$V_1 = \frac{nRT_1}{p_1} = \frac{(0.23\,mol)(8.31\,J/mol\,K)(309K)}{(3.5\times10^{5}\,Pa)}$$

$$V_1 = 1.7\times10^{-3}\,m^3$$

$$\left[V_3 = 5.6\times10^{-4}\,m^3\right] = \frac{1}{3}V_1$$

ISOTHERMALLY EXPANDED IMPLIES THAT $T_3 = T_4$, $V_4 = V_1$

so

$$p_3 V_3 = nRT_3 \qquad \text{since } T_3 = T_4,\ p_3V_3 = p_4V_4 = p_4V_1$$

$$p_4 V_4 = nRT_4$$

so

$$p_4 = p_3\frac{V_3}{V_1} = p_2\frac{V_3}{V_1}$$

$$= \frac{(1.1\times10^6\,\text{Pa})(5.6\times10^{-4}\,\text{m}^3)}{(1.7\times10^{-3}\,\text{m}^3)}$$

$$\left[\,p_4 = 3.6\times10^5\,\text{Pa}\,\right]$$

MAKING A CHART...

$p_1 = 3.5\times10^5\,\text{Pa}$	$V_1 = 1.7\times10^{-3}\,\text{m}^3$	$T_1 = 309\,\text{K}$
$p_2 = 3p_1 = 1.1\times10^6\,\text{Pa}$	$V_2 = V_1 = 1.7\times10^{-3}\,\text{m}^3$	$T_2 = 3T_1 = 927\,\text{K}$
$p_3 = p_2 = 1.1\times10^6\,\text{Pa}$	$V_3 = \frac{1}{3}V_2 = 5.6\times10^{-4}\,\text{m}^3$	$T_3 = T_1 = 309\,\text{K}$
$p_4 = 3.6\times10^5\,\text{Pa}$	$V_4 = V_1 = 1.7\times10^{-3}\,\text{m}^3$	$T_4 = T_3 = 309\,\text{K}$